REMARKS

In response to the Office Action dated April 14, 2004, claims 1 and 18 have been amended. New claims 20-23 have been added. Therefore, claims 1-23 are now in the case. In light of the amendments and arguments set forth herein, reexamination and reconsideration of the application are requested.

The Applicant wishes to thank the Examiner for the careful and thorough examination of the subject application and for pointing out the errors in the drawings and specification.

Drawing Objections

The Office Action objected to the drawings as failing to comply with 37 C.F.R. 1.84(p)(5) because they include the reference sign "330" that was not mentioned in the description.

In response, the Applicant has amended the specification to overcome this objection.

Specification Objections

The Office Action objected to the disclosure because on page 6, line 18, "drive 128" should have been "drive 118".

In response, the Applicant has amended the specification to overcome this objection.

Claim Rejections

Section 103(a) Rejections

The Office Action rejected claims 1-19 under 35 U.S.C. § 103(a) as being unpatentable over Sawhney et al. (U.S. Patent No. 6,571,024) in view of Driscoll, Jr. et al. (U.S. Patent Application Publication No. 2001/0010555). The Office Action stated that Sawhney et al. disclose all elements of the Applicant's claimed invention except that

"Sawhney et al. does not disclose how the omni-directional images are being taken." However, the Office Action stated that Driscoll, Jr. et al. "discloses an omni-directional camera comprising a reflecting surface and a lens (paragraph [0039])". Therefore, the Office Action asserted that it would have been obvious to one of ordinary skill in the art at the time the invention was made to have "combined the teachings of Driscoll, Jr. et al. with Sawhney et al. because Sawhney et al. discloses a camera capable of taking multi-view images and one of the ways of doing that is using a camera with a reflecting surface and a lens as disclosed by Driscoll, Jr. et al.."

In response, the Applicant respectfully traverses these rejections based on the amendments to claims 1 and 18 and the following legal and technical analysis. The Applicant submits that the combination of Sawhney et al. and Driscoll, Jr. et al. lack several elements or features of the Applicant's claimed invention. In particular, as explained in detail below, Sawhney et al. and Driscoll, Jr. et al. do not disclose, either explicitly or implicitly, the following material claimed features: (1) extracting a set of calibration parameters for the omni-directional camera by optimizing the objective function; and (2) defining an objective function as a deviation from the epipolar geometry for the tracked features. Further, Sawhney et al. and Driscoll, Jr. et al. fail to appreciate the advantages of these claimed features. In addition, there is no technical suggestion or motivation disclosed in Sawhney et al. and Driscoll, Jr. et al. to define these claimed features. Thus, the Applicant submits that the combination of Sawhney et al. and Driscoll, Jr. et al. cannot make obvious the Applicant's claimed features set forth above.

To make a prima facie showing of obviousness, all of the claimed features of an Applicant's invention must be considered, especially when they are missing from the prior art. If a claimed feature is not disclosed in the prior art and has advantages not appreciated by the prior art, then no prima facie showing of obviousness has been made. The Federal Circuit Court has held that it was an error not to distinguish claims over a combination of prior art references where a material limitation in the claimed system and its purpose was not taught therein. *In re Fine,* 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir.

1988). Moreover, as stated in the MPEP, if a prior art reference does not disclose, suggest or provide any motivation for at least one claimed feature of an Applicant's invention, then a prima facie case of obviousness has not been established (MPEP § 2142).

Amended Independent Claim 1

Amended independent claim 1 of the Applicant's claimed invention includes a method of self-calibrating an omni-directional camera having a reflecting surface and a lens. The method includes capturing a sequence of omni-directional images, and tracking a feature across the sequence of omni-directional images. The method further includes defining an objective function as an error between an actual feature location and a predicted feature location, and extracting a set of calibration parameters for the omni-directional camera by optimizing the objective function.

A catadioptric camera needs to be calibrated "in order to determine calibration parameters that will characterize incident light rays and thus account for optical distortion" (specification, page 2, lines 8-10). These calibration parameters includes an aspect ratio and an image skew (specification, page 3, lines 10-11). This set of calibration parameters are used to "remove distortion in images captured using the catadioptric camera system" (specification, page 8, lines 7-9). The set of calibration parameters are extracted 'by employing an optimization technique that will optimize the objective function" (specification, page 11, lines 1-3).

In contrast, Sawhney et al. merely disclose three-dimensional camera pose estimation where calibration parameters for the input video sequence are known and do not need to be extracted. Generally, Sawhney et al. disclose estimating a pose of an object when viewing the object from different camera positions (col. 1, lines 38-41 and lines 61-64). Part of this pose estimation involves decomposition of matrices using known calibration values. Specifically, Sawhney et al. defines a projection, p_i, in equation (1) that includes a camera calibration matrix, A (col. 5, lines 12-19). Given a point correspondence between a pair of frames, Sawhney et al. define a fundamental matrix constraint that is

used to compute a fundamental matrix, *F*, "by a number of known techniques" (col. 5, lines 27-31).

In Sawhney et al., "[W]ith the knowledge of the approximately known camera calibration, the *F* matrix can be decomposed into the camera pose matrices" (col. 5, lines 37-39). In addition, "in principal . . . the self-calibration techniques could also be employed . . . [H]owever, first, the stability of these techniques under arbitrary three dimensional motions is not guaranteed, and second, in practice, the only internal camera parameter that needs adjustment beyond the roughly known parameters is the focal length or scale. Aspect ratio, skew and the principal point are either generally known or nominal parameters are adequate" (col. 5, lines 42-51; emphasis added). Thus, in Sawhney et al., the calibration parameters for the camera that captured the input video sequence are known or are approximated.

Driscoll, Jr. et al. add nothing to the cited combination that would render the Applicant's claimed invention obvious. Driscoll, Jr. et al. merely describe a method for capturing a panoramic image. However, the Applicant's claimed feature of extracting a set of calibration parameters for the omni-directional camera by optimizing the objective function is not disclosed, discussed or suggested.

The combination of Sawhney et al. and Driscoll, Jr. et al. also fails to appreciate or recognize the advantages of the Applicant's claimed feature of extracting a set of calibration parameters for the omni-directional camera by optimizing the objective function. In particular, the set of calibration parameters is used to "remove distortion in images captured using the catadioptric camera system" (specification, page 8, lines 7-9). Neither Sawhney et al. nor Driscoll, Jr. et al. discuss this claimed feature of the Applicant's invention.

The Applicant, therefore, submits that obviousness cannot be established since the combination of Sawhney et al. and Driscoll, Jr. et al. fails to teach, disclose, suggest or provide any motivation for the Applicant's claimed feature of extracting a set of calibration

parameters for the omni-directional camera by optimizing the objective function. In addition to explicitly lacking this feature, the combination of Sawhney et al. and Driscoll, Jr. et al. also fails to implicitly disclose, suggest, or provide motivation for this feature. Further, the combination of Sawhney et al. and Driscoll, Jr. et al. fails to appreciate advantages of this claimed feature.

Therefore, as set forth in *In re Fine* and MPEP § 2142, the combination of Sawhney et al. and Driscoll, Jr. et al. does not render the Applicant's claimed invention obvious because each of the references is missing at least the material feature of the Applicant's claimed invention outlined above. Consequently, because a prima facie case of obviousness cannot be established due to the lack of "some teaching, suggestion, or incentive supporting the combination", the rejection must be withdrawn. ACS Hospital Systems, Inc. v. Montefiore Hospital, 732 F.2d 1572, 1577, 221 USPQ 929, 933 (Fed. Cir. 1984); MPEP 2143.01.

Accordingly, the Applicant respectfully submits that amended independent claim 1 is patentable under 35 U.S.C. § 103(a) over Sawhney et al. in view of Driscoll, Jr. et al. based on the amendments to claim 1 and the legal and technical arguments set forth above and below. Moreover, claims 2-11 depend from amended independent claim 1 and are also nonobvious over Sawhney et al. in view of Driscoll, Jr. et al. (MPEP § 2143.03). The Applicant, therefore, respectfully requests reexamination, reconsideration and withdrawal of the rejection of claims 1-11.

Independent Claim 12

Independent claim 12 of the Applicant's claimed invention includes a method of self-calibrating a catadioptric camera system having mirrors and lenses. The method includes obtaining a sequence of omni-directional images of a scene from the catadioptric camera, tracking features within the scene across the sequence of omni-directional images, and characterizing epipolar geometry based on an initial set of calibration parameters. The method further includes defining an objective function as a deviation from the epipolar geometry for the tracked features, and minimizing the objective function

to obtain calibration parameters.

The object function of the Applicant's claimed invention "can be defined as the deviation from the epipolar geometry for features across two images" (specification, page 10, lines 28-30). "In other words, the objective function is the error between the actual and predicted feature locations based on epipolar geometry" (specification, page 10, lines 30-31). Thus, the Applicant's claimed invention includes using a deviation from the epipolar geometry to define an objective function.

In contrast, Sawhney et al. merely disclose constraining features to be on epipolar lines. More specifically, "both forward and reverse displacement fields are computed" between pairs of frames "by constraining the displacements to lie on epipolar lines" (col. 4, lines 32-40). In other words, while Sawhney et al. requires that features be constrained to epipolar lines to compute displacements, the Applicant's claimed invention uses deviations from the epipolar geometry to define an objective function.

Driscoll, Jr. et al. add nothing to the cited combination that would render the Applicant's claimed invention obvious. Driscoll, Jr. et al. merely describe a method for capturing a panoramic image. However, the Applicant's claimed feature of defining an objective function as a deviation from the epipolar geometry for the tracked features is not disclosed, discussed or suggested.

The combination of Sawhney et al. and Driscoll, Jr. et al. also fails to appreciate or recognize the advantages of the Applicant's claimed feature of defining an objective function as a deviation from the epipolar geometry for the tracked features. In particular, the objective function is used to extract optimal calibration parameters by optimizing the objective function (specification, page 11, lines 1-3). Neither Sawhney et al. nor Driscoll, Jr. et al. discuss this claimed feature of the Applicant's invention.

The Applicant, therefore, submits that obviousness cannot be established since the combination of Sawhney et al. and Driscoll, Jr. et al. fails to teach, disclose, suggest or

provide any motivation for the Applicant's claimed feature of defining an objective function as a deviation from the epipolar geometry for the tracked features. In addition to explicitly lacking this feature, the combination of Sawhney et al. and Driscoll, Jr. et al. also fails to implicitly disclose, suggest, or provide motivation for this feature. Further, the combination of Sawhney et al. and Driscoll, Jr. et al. fails to appreciate advantages of this claimed feature.

Therefore, as set forth in *In re Fine* and MPEP § 2142, the combination of Sawhney et al. and Driscoll, Jr. et al. does not render the Applicant's claimed invention obvious because each of the references is missing at least the material feature of the Applicant's claimed invention outlined above. Consequently, because a prima facie case of obviousness cannot be established due to the lack of "some teaching, suggestion, or incentive supporting the combination", the rejection must be withdrawn. ACS Hospital Systems, Inc. v. Montefiore Hospital, 732 F.2d 1572, 1577, 221 USPQ 929, 933 (Fed. Cir. 1984); MPEP 2143.01.

Accordingly, the Applicant respectfully submits that independent claim 12 is patentable under 35 U.S.C. § 103(a) over Sawhney et al. in view of Driscoll, Jr. et al. based on the legal and technical arguments set forth above and below. Moreover, claims 13-17 depend from independent claim 12 and are also nonobvious over Sawhney et al. in view of Driscoll, Jr. et al. (MPEP § 2143.03). The Applicant, therefore, respectfully requests reexamination, reconsideration and withdrawal of the rejection of claims 12-17.

Amended Independent Claim 18

Amended independent claim 18 of the Applicant's claimed invention includes a method for obtaining optimal calibration parameters to calibrate a catadioptric camera system. The method includes tracking features across an image sequence captured by the catadioptric camera system, and identifying pairwise correspondence between the tracked features. The method further includes defining an objective function in terms of an error metric based deviation from epipolar geometry for the pairwise tracked features,

minimizing the error metric to minimize the objective function, and extracting the optimal calibration parameters from the minimized objective function.

In contrast, as argued above in regards to claims 1 and 12, Sawhney et al. merely disclose three-dimensional camera pose estimation where calibration parameters for the input video sequence are known and do not need to be extracted, the requirement that constrains features to be on epipolar lines. As noted above, neither Sawhney et al. nor Driscoll, Jr. et al. disclose, discuss or suggest the Applicant's claimed features of defining an objective function in terms of an error metric based deviation from epipolar geometry for the pairwise tracked features and extracting the optimal calibration parameters from the minimized objective function. In addition, as noted above, the combination of Sawhney et al. and Driscoll, Jr. et al. also fails to appreciate or recognize the advantages of these claimed features of the Applicant's invention.

The Applicant, therefore, submits that obviousness cannot be established since the combination of Sawhney et al. and Driscoll, Jr. et al. fails to teach, disclose, suggest or provide any motivation for the Applicant's claimed features of defining an objective function in terms of an error metric based deviation from epipolar geometry for the pairwise tracked features and extracting the optimal calibration parameters from the minimized objective function. In addition to explicitly lacking these features, the combination of Sawhney et al. and Driscoll, Jr. et al. also fails to implicitly disclose, suggest, or provide motivation for these features. Further, the combination of Sawhney et al. and Driscoll, Jr. et al. fails to appreciate advantages of these claimed features.

Therefore, as set forth in *In re Fine* and MPEP § 2142, the combination of Sawhney et al. and Driscoll, Jr. et al. does not render the Applicant's claimed invention obvious because each of the references is missing at least the material features of the Applicant's claimed invention outlined above. Consequently, because a prima facie case of obviousness cannot be established due to the lack of "some teaching, suggestion, or incentive supporting the combination", the rejection must be withdrawn.

ACS Hospital Systems, Inc. v. Montefiore Hospital, 732 F.2d 1572, 1577, 221 USPQ 929, 933 (Fed. Cir. 1984); MPEP 2143.01.

Accordingly, the Applicant respectfully submits that amended independent claim 18 is patentable under 35 U.S.C. § 103(a) over Sawhney et al. in view of Driscoll, Jr. et al. based on the amendments to claim 18 and the legal and technical arguments set forth above and below. Moreover, claim 19 depends from amended independent claim 18 and is also nonobvious over Sawhney et al. in view of Driscoll, Jr. et al. (MPEP § 2143.03). The Applicant, therefore, respectfully requests reexamination, reconsideration and withdrawal of the rejection of claims 18 and 19.

Conclusion

In view of the amendments to claims 1 and 18 and the arguments set forth above, the Applicant submits that claims 1-23 of the subject application are in condition for immediate allowance. The Examiner is respectfully requested to withdraw the outstanding rejections of the claims and to pass this application to issue.

In an effort to expedite and further the prosecution of the subject application, the Applicant kindly invites the Examiner to telephone the Applicant's attorney at (805) 278-8855 if the Examiner has any comments, questions or concerns, wishes to discuss any aspect of the prosecution of this application, or desires any degree of clarification of this response.

Respectfully submitted,
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